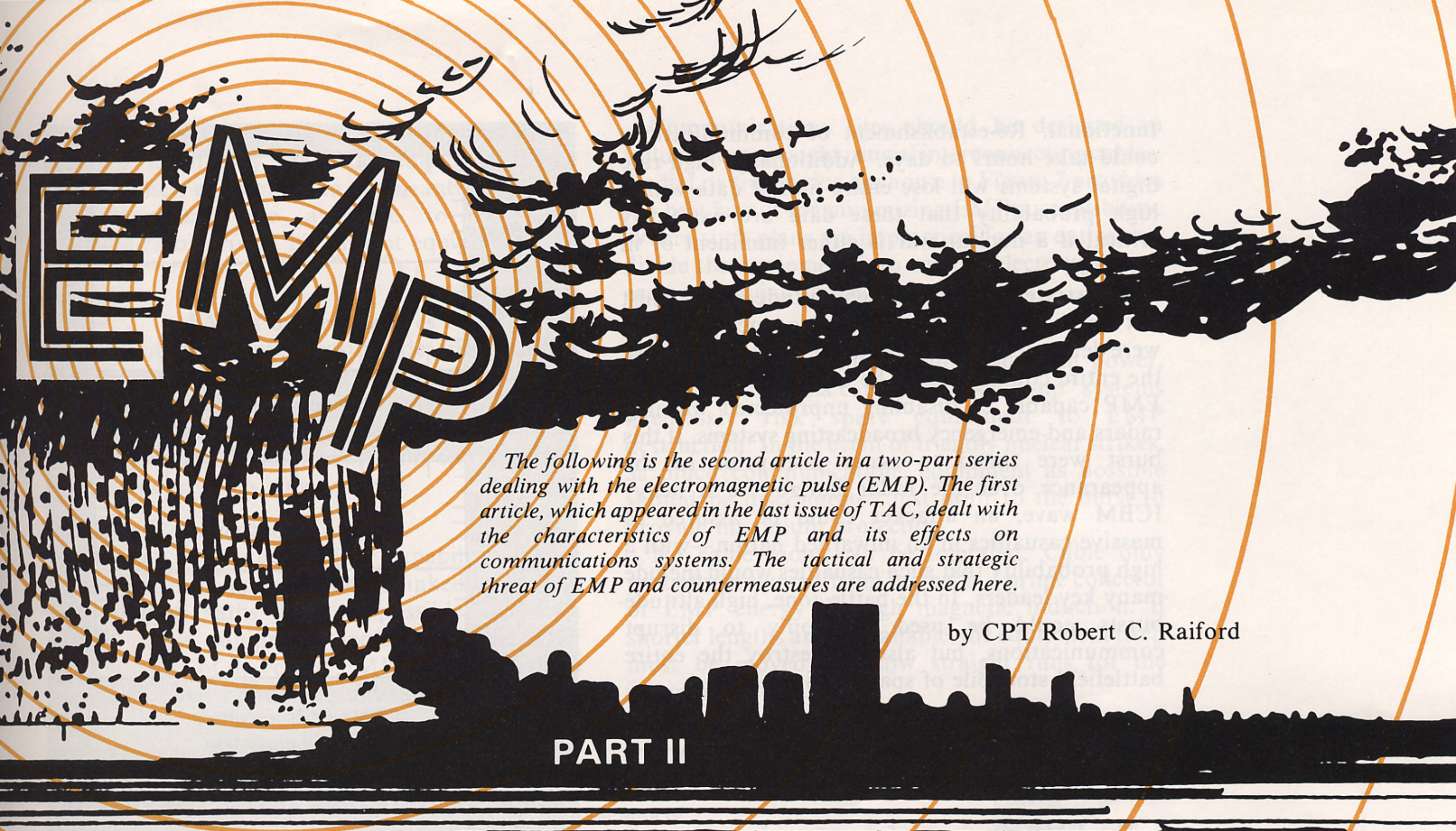


EMP

The following is the second article in a two-part series dealing with the electromagnetic pulse (EMP). The first article, which appeared in the last issue of TAC, dealt with the characteristics of EMP and its effects on communications systems. The tactical and strategic threat of EMP and countermeasures are addressed here.

by CPT Robert C. Raiford

PART II

Thus far the electromagnetic pulse and its possible effects on equipment have been examined. Equipment damage in itself, however, is not the major concern to the military communicator and his commander. It is the very real possibility of total loss of command and control of friendly forces that constitutes the EMP threat.

Nuclear warfare and EMP must not be dismissed as unlikely possibilities in open conflict with Soviet forces. Joseph Douglas in his examination of Soviet nuclear philosophy and tactics in *The Soviet Theater Nuclear Offensive*, observes the following:

> In any Soviet discussion of nuclear war, there is one word that dominates above all others—decisive...The war would be a decisive military and political victory; and the *primary instrument* in bringing this about is the *initial, mass, simultaneous, in-depth nuclear strike*...The employment of nuclear weapons in itself is...accomplished...suddenly and en masse, *to the entire depth of the enemy's combat deployment. (Italics are mine.)*

Thus a nuclear environment is a real possibility, and its accompanying EMP threat can play a significant part in the outcome of the struggle.

The EMP threat can be regarded from tactical and strategic viewpoints corresponding, respectively, with the tactical surface and high altitude bursts.

Tactical Aspects of the EMP Threat

It will be remembered from earlier discussion that the surface or low altitude burst radiates vertically polarized EMP which rapidly decreases with distance. Considering current defensive doctrine, two appropriately placed tactical nuclear weapons could saturate a division defensive sector forward of the brigade rear boundaries. The resulting EMP would destroy all FM and HF nets as well as a major portion of the division multichannel system. If, prior to the nuclear strike, enemy forces employ EMP countermeasures, they would find themselves capable of launching a well-coordinated assault against individual defending units unable to coordinate with brigade or division headquarters, with each other, or with supporting artillery before being overrun.

Fast-moving mechanized operations are extremely dependent on radio communications for command and control. Without constant communications, the success of this type of assault is extremely uncertain. Enemy final defensive fires containing tactical nuclear weapons could create just this situation.

In either scenario described above, the tactical communicator is faced with a massive repair and resupply problem. Additionally, command and control functions dependent on digital systems such as automatic switchboards, tactical operations systems, TACFIRE, and joint tactical information distribution systems are severely threatened because of the increased EMP susceptibility of digital data systems.

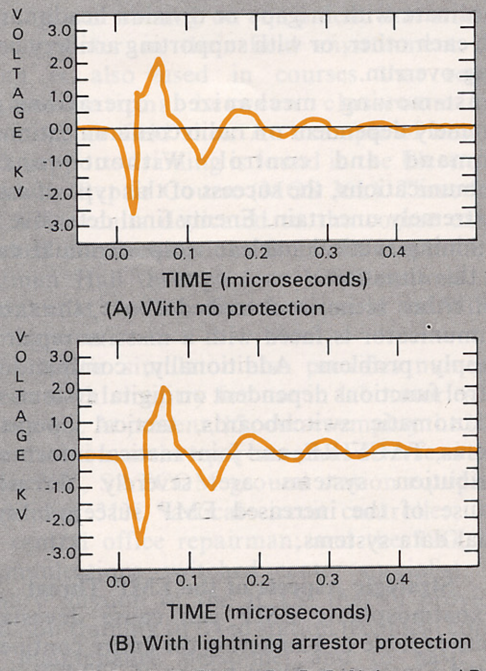
Strategic Aspects of the EMP Threat

Exoatmospheric EMP can cause devastating effects capable of blanketing the entire continental United States at a burst height of 320 kilometers and a yield in the megaton range. Because of the broad, distributed coverage of this threat, unhardened telephone circuits and teletype landlines, switching terminals, and switchboards are not anticipated to survive and remain functional. Re-establishment of communications could take hours to days. Additionally, high rate digital systems will lose entire files of data with a high probability that these data are extremely critical if a nuclear war is either imminent or in progress.

The strategic value of high altitude bursts must not be discounted. If an orbiting nuclear device were detonated over the center of the United States, the entire country would be blanketed with severe EMP capable of disabling unprotected warning radars and emergency broadcasting systems. If this burst were timed to occur just prior to the appearance over the radar horizon of a heavy ICBM wave, an attacker could be assured of massive casualties in an unwarned nation—with a high probability that such casualties would include many key leaders. In the battle zone, high altitude bursts could be used not only to disrupt communications, but also to destroy the entire battlefield stockpile of spare equipment.

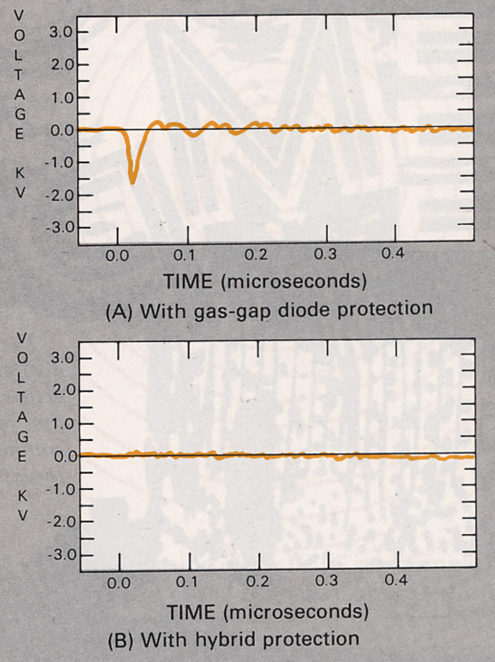
EMP DESIGN TECHNIQUES AND COUNTERMEASURES

The EMP response of a system is a complex phenomenon. A limited EMP data base, the pulse's extraordinarily fast rise time, and its huge voltage magnitude make positive system response predictions and absolute countermeasure proposals extremely difficult tasks.



SOURCE: Dr. C. R. Fisher, Dr. D. B. Nelson, and P. R. Barnes, "EMP and the Radio Amateur," QST, September 1975, p. 42.

Figure 5. Typical EMP response of a VHF gain antenna connected to a receiver.



SOURCE: Dr. C. R. Fisher, Dr. D. B. Nelson, and P. R. Barnes, "EMP and the Radio Amateur," QST, September 1975, p. 42.

Figure 6. EMP response for antenna in Fig. 5 with EMP surge suppressors installed.

EMP Design Techniques

While a detailed examination of EMP design techniques would not be within the scope of this article, the following brief discussion will give an appreciation of the design problems EMP causes.

Surge-limiting devices are perhaps the most obvious solution to the EMP threat. Lightning arrestors, the most commonly used surge protectors, are useless against EMP. (See Figures 5a and b.) The pulse's extremely fast rise time will allow destructive voltages (400 per cent of the design breakdown voltage) to reach the electronic circuitry before breakover can occur. Hybrid protection consisting of gas-gap diodes and switching diodes offers a solution (see Figures 6a and b) but their greater size and cost make complete protection of switchboards, patch panels, and other high-line-capacity systems unfeasible at this time.

EMP filtering is a practical impossibility because of the wide frequency spectrum involved. Additionally, the danger of fortuitous matching is present wherein a filter actually enhances the EMP signal.

Good shielding provides excellent protection, but its design is a very exacting process requiring careful attention to every detail of the system. Generally, good cabling, radio frequency interference and electromagnetic interference design procedures will provide a very acceptable degree of EMP protection.

Improved surge protection, shielding and EMP-resistant technology are being employed in the design of new equipment. In the meantime, certain countermeasures are available to help the communicator protect his present equipment.

EMP Countermeasures

Many of the countermeasures described in this section represent nothing more than sound communications planning and installation procedures. Their implementation therefore should require little additional time or effort on the part of the communications supervisor.

Planning Considerations

Provide alternate routing capability. Every communications node should be linked by at least two different paths. If at all possible, one path should utilize equipment operating in the SHF band because of decreased EMP intensity at these frequencies. An area communications grid utilizing "backbone" microwave transmission to interconnect all signal centers provides an acceptable alternate path.

Provide alternate means of communication, such as air or motor messenger, until electronic communications can be reestablished.

Locate communications complexes as far away as practical from priority targets, such as major headquarters. Maximizing use of long locals and radio remoting equipment will provide a double benefit: (1) lessening of equipment exposed to highest EMP and blast intensities from tactical surface bursts; and (2) reduction of electronic signature of command center so as to belie its size or importance.

Communications sites should be designed to utilize short, straight runs of interconnecting cables. Radial or tree wiring as shown in Figure 7 provides the best layout for minimizing EMP susceptibility. Where such plans are impractical for an entire site, divide the equipment into smaller electrical zones, each employing radial or tree layout.

Operational Considerations

Disconnect all unused equipment from power, signal, and antenna cables. "Hot back-up" systems needlessly risk spare equipment to EMP destruction. In the event of friendly nuclear strikes, as much communications equipment as possible should be disconnected just prior to the burst to provide maximum protection.

No cable loops can be tolerated. Cable only partially unwound from its reel is a prime collector of EMP energy through magnetic induction. If shorter lengths are unavailable, the equipment itself must be moved to allow straight runs for the interconnecting cables.

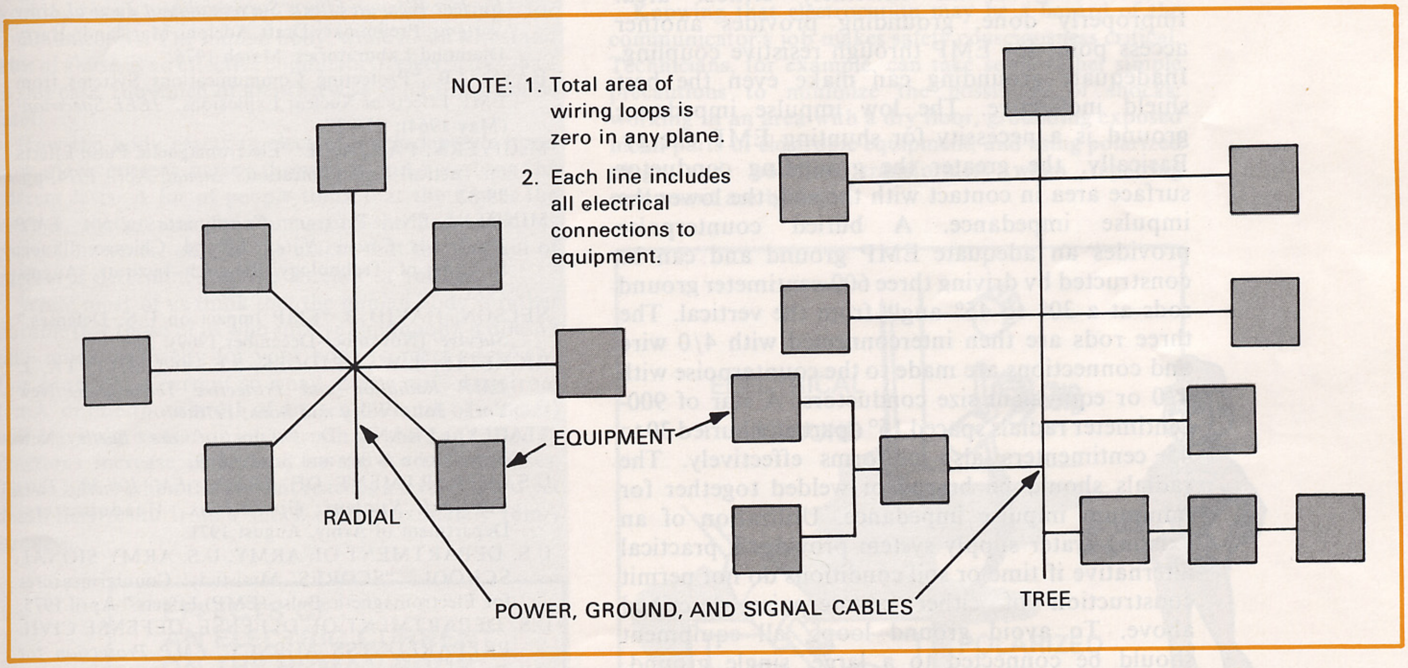


Figure 7. Radial and tree wiring schematics.

All cables should be buried. Three feet is considered a minimum depth for reasonable EMP protection, but any depth is better than surface or aerial construction. The recommended wiring plans in Figure 7 emphasize a total elimination of cable loops in any plane by bunching signal, power, and ground connectors along single paths. To prevent power line interference, bury the cables one above the other with a minimum interval of 30 centimeters between signal and power conductors.

Most sensitive equipment already employs some shielding to prevent electromagnetic or radio frequency interference. This shielding also provides EMP protection provided that it is properly maintained. Accordingly, all doors (both shelter and equipment), equipment drawers, and signal entrance panels must be kept closed during normal operation to ensure shield integrity. Cable connectors are a major source of EMP pickup. RF gaskets should be periodically inspected, and all metal-to-metal mating surfaces must be kept clean. Cable connections must be tight at all times.

Antenna polarization can provide some reduction in EMP pickup depending on the situation. In forward areas, the tactical EMP threat is primary, and horizontal antenna polarization should be preferred. Extreme rear areas lying in the strategic theater would derive more protection from vertical polarization. If the particular EMP threat cannot be identified, consider that exoatmospheric bursts cover wide areas and have a greater tendency to prove counterproductive to the employing force as compared to surface bursts. Therefore, tactical surface bursts are more likely; and horizontal is the polarization of choice unless specific intelligence indicates otherwise.

Grounding is an extremely critical area. Improperly done, grounding provides another access point for EMP through resistive coupling. Inadequate grounding can make even the best shield ineffective. The low impulse impedance ground is a necessity for shunting EMP energy. Basically, the greater the grounding conductor surface area in contact with the soil, the lower the impulse impedance. A buried counterpoise provides an adequate EMP ground and can be constructed by driving three 600-centimeter ground rods at a 30° to 45° angle from the vertical. The three rods are then interconnected with 4/0 wire and connections are made to the counterpoise with 4/0 or equivalent size conductors. A star of 900-centimeter radials spaced 15° apart and buried 30 to 45 centimenters also performs effectively. The radials should be brazed or welded together for minimum impulse impedance. Utilization of an existing water supply system provides a practical alternative if time or soil conditions do not permit construction of either counterpoise described above. To avoid ground loops, all equipment should be connected to a large, single ground. Where this is not practical, the electrical zoning referred to earlier may be used.

CONCLUSIONS AND RECOMMENDATION

The electromagnetic pulse is a very real, very complex, very serious threat to electrical and electronic devices and, hence, a threat to our ability to command and control forces on a nuclear battlefield. The EMP threat has been realized, and developmental items are being hardened against its effects. However, the military communicator and his commander are dependent upon presently available equipment which is not EMP-hardened. This presents a grave, but not hopeless, situation. The countermeasures discussed in Part II of this article can be successfully employed to reduce EMP effects on present equipment with minimal doctrinal revision. All that remains is education of supervisory personnel through courses of instruction for officers and senior NCOs.

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